TITLE OF THE INVENTION

LINK MANAGER AND LINK MANAGEMENT METHOD

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to a link manager and a link management method for managing plural types of links installed on a mobile host.

RELATED BACKGROUND ART

In recent years, a variety of communication paths (hereinafter referred to as "links") adapted to IP (Internet Protocol) have emerged one after another, irrespective of wireless and wired links, and became available under various environments. For this reason, a moving host, i.e., a mobile host became allowed to move while maintaining communications from link to link by making use of IP mobility protocols such as Mobile IP and others. Further, it became feasible to use plural types of links at a certain location and to load a single mobile host simultaneously with plural types of links because of attainment of downsizing and lower power consumption of interfaces with these links (connecting devices with the links) and implementation of programmable interface apparatus by software wireless means and the like.

SUMMARY OF THE INVENTION

The present invention has been accomplished under

such circumstances and an object of the invention is to provide comfortable connection environments for the user of the mobile host by substantiating automatic selection of a link complying with a condition requested by the user or applications, from plural types of links installed on the mobile host.

For accomplishing the above object, a link manager according to the present invention is configured to comprise detecting means for detecting what link is installed; managing means for defining a plurality of link metrics indicating characteristics of each link detected and managing data corresponding to the respective link metrics on a table; and selecting means for selecting a link having link metrics complying with a given condition.

The link manager may be configured so that the managing means generates a record comprised of the data corresponding to the respective link metrics, for each link on the table.

The link manager may be configured so that when a new link corresponding to neither record is detected, the managing means generates a record corresponding to the new link and records data corresponding to link metrics of the link and so that when a link corresponding to either record becomes undetectable, the managing means deletes the record.

The link manager may be configured to comprise link metric rank assigning means for assigning ranks to the respective link metrics, based on a predetermined preference; and data rank assigning means for assigning ranks to the data corresponding to the respective link metrics; and configured so that when the predetermined preference is given, the selecting means selects a link corresponding to a record having data with a highest rank thus assigned, at a link metric with a highest rank.

The link manager may be configured so that when there exist a plurality of records having data with the highest rank thus assigned, the selecting means selects a link corresponding to a record having data with a highest rank thus assigned, at a link metric with a next highest rank.

A link management method according to the present invention is configured to comprise a detecting step of detecting what link is installed; a managing step of defining a plurality of link metrics indicating characteristics of each link detected and managing data corresponding to the respective link metrics on a table; and a selecting step of selecting a link having link metrics complying with a given condition.

The link management method may be configured to comprise a step of generating a record comprised of the

data corresponding to the respective link metrics, for each link on the table.

The link management method may be configured to comprise a step wherein when a new link corresponding to neither record is detected, a record corresponding to the new link is generated and data corresponding to link metrics of the link is recorded and wherein when a link corresponding to either record becomes undetectable, the record is deleted.

The link management method may be configured to comprise a step of assigning ranks to the respective link metrics, based on a predetermined preference; and a step of assigning ranks to the data corresponding to the respective link metrics; and configured so that the selecting step comprises a step of, when the predetermined preference is given, selecting a link corresponding to a record having data with a highest rank thus assigned, at a link metric with a highest rank.

The link management method may be configured so that the selecting step comprises a step of, when there exist a plurality of records having data with the highest rank thus assigned, selecting a link corresponding to a record having data with a highest rank thus assigned, at a link metric with a next highest rank.

A program according to the present invention is configured to effect execution of the following processes: a process of detecting what link is installed; a process of defining a plurality of link metrics indicating characteristics of each link detected and managing data corresponding to the respective link metrics on a table; a process of generating a record comprised of the data corresponding to the respective link metrics, for each link on the table; a process of assigning ranks to the respective link metrics, based on a predetermined preference; a process of assigning ranks to the data corresponding to the respective link metrics; and a process of, when the predetermined preference is given, selecting a link corresponding to a record having data with a highest rank thus assigned, at a link metric with a highest rank.

The program may be configured to comprise a process of, when there exist a plurality of records having data with the highest rank thus assigned, selecting a link corresponding to a record having data with a highest rank thus assigned, at a link metric with a next highest rank.

The program may be configured to comprise a process wherein when a new link corresponding to neither record is detected, a record corresponding to

the new link is generated and data corresponding to link metrics of the link is recorded and wherein when a link corresponding to either record becomes undetectable, the record is deleted.

A recording medium according to the present invention is a computer-readable memory in which the program as set forth in either one of Claim 11 to Claim 13 is recorded.

According to the present invention, as described above, a link complying with a condition requested by the user or applications is automatically selected out of a plurality of various links installed on a mobile host, which makes it feasible to provide comfortable connection environments for the user of the mobile host.

The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus are not to be considered as limiting the present invention.

Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and

scope of the invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram showing the placement of the link manager in a protocol stack provided in the mobile host.

Fig. 2 is a block diagram showing the schematic structure of the link manager.

Fig. 3 is a diagram showing the typical link metrics used when the link manager manages the links.

Fig. 4 is a diagram showing an example of preferences.

Fig. 5 is a flowchart showing the operation of the link manager.

Fig. 6 is a diagram showing a link management table used in a link detecting process.

Fig. 7 is a flowchart of a link selecting process.

Fig. 8 is a diagram showing priority ranks of the data corresponding to the respective link metrics.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 is a diagram showing the placement of the link manager in a protocol stack provided in the mobile host. Fig. 2 is a block diagram showing the schematic structure of the link manager 1. As shown in Fig. 1, the link manager 1 is located between a group of links ($link_1$ to $link_m$) installed on the mobile host, and IP

mobility protocols 2. The link manager 1 provides only a link most complying with requirements given by the user and/or applications, for the IP mobility protocols 2 while managing states of the respective links.

As shown in Fig. 2, the link manager 1 comprises detecting means 20 for detecting what link ($link_1$ to $link_m$) is installed; managing means 21 for defining a plurality of link metrics indicating characteristics of each link detected by the detecting means 20 and managing data corresponding to the respective link metrics on a table; and selecting means 22 for selecting a link having link metrics complying with the given requirements and providing the link thus selected, for the IP mobility protocols 2. The link manager 1 also comprises link metric rank assigning means 23 for assigning ranks to the respective link metrics, based on a predetermined preference; and data rank assigning means 24 for assigning ranks to data corresponding to the respective link metrics.

In Fig. 1, the IP mobility protocols 2 perform mobility management for maintaining communications, whenever the link manager 1 stops providing a link used heretofore ($link_1$) and provides a new link ($link_2$) instead.

The mobility management by the IP mobility protocols 2 is carried out as follows. For example,

where a new link is provided from the link manager 1 while Mobile IPv6 (Internet Protocol version 6) is used as an IP mobility protocol, it acquires a c/o address (Care-of Address) from the link, puts a correspondence between a home address and the c/o address into a Binding Update packet, and sends it to a home agent and a correspondent host. The home address herein is an address independent of the links, which is used by transport protocols 3 (Transport Protocols) and applications 4 in Fig. 1. The transport protocols 3 are, for example, TCP, UDP, and so on. On the other hand, the c/o address is an address dependent on the link, which is used for forwarding a packet directed to the home address, to the link currently under use. Mobile IPv6 repeatedly carries out the mobility management at every switching of the link provided by the link manager 1, so as to maintain communications between the mobile host and the correspondent host.

Fig. 3 is a diagram showing typical link metrics used when the link manager 1 manages the links. The link metrics are indicators indicating various characteristics of each link and, for example, each of the metrics is defined as shown in Fig. 2. The metric named "technology standard" is a link metric indicating a standard of technology on which the link is based. The technology standards are defined by various

standardization organisms; for example, there are IMT-2000, IEEE802.11, IEEE802.3z, Bluetooth, and so on. The metric named "cost" is a link metric indicating cost necessary for use of the link. The cost is determined by a billing scheme and a cost per billing unit. The billing scheme is either of free (no charge), flat rate billing (fixed charge scheme), time-based billing (time charge scheme), usage-based billing (as-used charge scheme), and so on. The metric named "link type" is a link metric indicating whether the link is a wired link or a wireless link. The metric named "tolerable speed" is a link metric indicating a tolerable moving speed of the mobile host capable of using the link. The metric named "QoS support" is a link metric indicating whether packet transmission with link-level QoS is supported. The metric named "encryption support" is a link metric indicating whether link-level packet encryption is supported. The metric named "power consumption" is a link metric indicating power consumption of the interface device of the link. The metric named "sleep mode support" is a link metric indicating whether a low-power consumption mode (sleep mode) is available during periods of no packet transmission at the link. An example of the low-power consumption mode is an intermittent reception action in which the receiver is intermittently

activated at a wireless link.

The metric named "enabled/disabled" is a link metric indicating whether the user forcedly has set the link enabled or disabled. The metric named "connectivity" is a link metric indicating whether the link is connectible. The metric named "throughput" is a link metric indicating a measured value of throughput of the link. The metric named "packet loss rate" is a link metric indicating a measured value of packet loss rate. The metric named "latency" is a link metric indicating a measured value of packet transmission latency of the link.

These link metrics are classified under constant metrics and variable metrics. The metrics of technology standard, cost, link type, tolerable speed, QoS support, encryption support, power consumption, and sleep mode support are constant metrics, while the metrics of enabled/disabled, connectivity, throughput, packet loss rate, and latency are variable metrics. Since the constant link metrics can be uniquely determined, the link manager 1 does not have to monitor these link metrics. However, since the variable link metrics can vary with a lapse of time, the link manager 1 has to monitor these link metrics.

The diversity of the link metrics as described above makes it very troublesome for the user or the

applications to designate the individual link metrics according to requirements. Therefore, in order to facilitate the designation of the link metrics, the present embodiment is configured so that in determination of precedence of the links, the link manager 1 makes a pattern of priorities of link metrics desired to give priority and defines it as a preference.

Fig. 4 is a diagram showing an example of preferences. "Cost" (cost priority preference) is a preference for such selection of a link as to minimize the cost. "Quality" (transmission quality priority preference) is a preference for such selection of a link as to maximize the transmission quality. "Security" (security priority preference) is a preference for such selection of a link as to ensure security. "Communication time" (communication time priority preference) is a preference for such selection of a link as to maintain communications over a period as long as possible.

The following will describe the operation of the link manager 1 constructed as described above. Fig. 5 is a flowchart showing the operation of the link manager 1. First, the link manager 1 performs link detection (link detecting process) (step S1). This link detecting process is a process of detecting what links are installed on the mobile host. By this link

detecting process, it is determined whether a new link is installed or whether a link having been used heretofore is uninstalled.

Fig. 6 is a diagram showing a link management table used in the link detecting process. The link management table is comprised of a plurality of records corresponding to the respective links. A record includes data corresponding to the link metrics of one link.

When a link corresponding to neither of the records in this link management table is detected, the link manager determines that a new link was installed on the mobile host (step S2), and then performs record addition (a record adding process) (step S3). This record adding process is a process of adding a new record to the link management table to record the link metrics of the link. Since the variable link metrics are not gained at this stage, only the constant link metrics are recorded. The constant link metrics are obtained by a method in which the user manually notifies the link manager 1 of the link metrics, a method of automatically notifying the link manager 1 of the link metrics upon mounting of the interface of the link, and so on.

On the other hand, when a link existing as a record in the link management table becomes

undetectable, the link manager determines that the link was uninstalled (step S4), and then performs record deletion (a record deleting process) (step S5). This record deleting process is a process of deleting the associated record from the link management table.

Then the link manager 1 performs variable link metrics monitor (a variable link metrics monitoring process) (step S6). The variable link metrics monitoring process is a process of monitoring the variable link metrics recorded in the link management table. The variable link metrics except for the metric "enabled/disabled," which is a metric set by the user, vary their states, depending upon movement of the mobile host and others. The connectivity can or cannot be obtained from the interface device of the link. When it cannot be obtained, the connectivity is detected, for example, by making use of Router advertisement packets for advertising locations of IPv6 routers to the mobile host. Since Router advertisement packets are periodically sent from the routers to the mobile host, it can be determined that the link is connectible as long as the mobile host can periodically receive the Router advertisement packets and that the link is unconnectible if the mobile host fails to receive the Router advertisement packets.

The throughput, packet loss rate, and

transmission latency can or cannot be obtained from the interface device of the link as well. When they cannot be obtained, they are determined, for example, by use of the Router advertisement packets of IPv6. The throughput can be calculated by the equation (Eq. 1) below, using a length L of a Router advertisement packet, a send time Ts of the Router advertisement packet at a router, and a receive time Tr of the Router advertisement packet at the mobile host.

[Eq. 1]

$$\text{Throughput [bps]} = L/(T_r - T_s)$$

The packet loss rate can be calculated by the equation (Eq. 2) below, using the number P of Router advertisement packets received, and a maximum sequence number S_{max} and a minimum sequence number S_{min} included in the received Router advertisement packets.

[Eq. 2]

$$\text{Packet loss rate [\%]} = P/(S_{max} - S_{min})$$

The transmission latency can be calculated by the equation(Eq. 3) below, based on reception of a Router advertisement packet including a send time at a router.

[Eq. 3]

$$\text{Transmission latency [sec]} = T_r - T_s$$

If the throughput, the packet loss rate, and the transmission latency vary largely, each of them can be obtained as an average value.

Then the link manager 1 determines whether there is any change in the variable link metrics (step S7). A decision is made by comparing the result of the monitoring with the data recorded in the link management table. When there is a change in the link metrics, the link manager 1 performs variable link metrics update (a link metrics updating process) (step S8). This link metrics updating process is a process of recording new variable link metrics in the associated record of the link management table.

Then the link manager 1 performs link selection (a link selecting process) (step S9). The link selecting process is a process of selecting a link most adapted to the preference designated by the user or the applications. In this process, the link manager 1 provides only the newly selected link to the higher IP mobility management (IP mobility protocols) and then moves to the link detecting process at step S1.

Fig. 7 is a flowchart of the link selecting process at step S9 of Fig. 6. The link manager 1 sorts all the records in the link management table shown in Fig. 6, using the link metric with the highest priority in Fig. 4 as a key. Specifically, noting the link metric with the highest priority, it is set as n=1 (step ST1) and all the records are selected (step ST2). Here ranks indicating precedence levels are assigned to

the data corresponding to the respective link metrics. Fig. 8 is a diagram showing the priority ranks of the data corresponding to the respective link metrics. For example, as to the data corresponding to the link metric "cost," "free" is provided with the highest priority and "time-based" with the lowest priority. The records selected at step ST2 are sorted based on these priorities assigned to the data (step ST3). Then it is determined whether the number of records having the data with the highest priority is equal to one (step ST4). If the number is one, the link identified by the top record is selected (step ST5).

On the other hand, if the number of records having the data with the highest priority is not equal to one, attention is then focused on the link metric with the second highest priority (step ST6), it is set as n=n+1 (step ST7), and it is then determined whether the value of n+1 is equal to an ordinal rank of the link metric with the lowest priority (step ST8). Since the ordinal rank at this stage is still the second, the link manager proceeds to step ST3 to sort the records according to the ranks assigned to the data corresponding to the link metric with the second priority (step ST4).

This operation is continued before the number of records having the data with the highest priority

becomes equal to one or before the sorting with the link metric of the lowest rank as a key is finished. After the sorting with the link metric of the lowest rank as a key is finished, the link manager selects the link corresponding to the record at the top position (step ST5). Before reaching the lowest rank, the link manager transfers to step ST3. Since the lowest rank is the twelfth in Fig. 4, it is determined at step ST8 whether the sorting with the twelfth link metric as a key is finished.

The present embodiment was described about the operation carried out when the user or the applications designated one preference and provided it for the link manager, but the present invention is not limited to this example and also permits such an operation that the applications designate a plurality of preferences and the link manager provides a plurality of links complying with the preferences. The applications sometimes have requirements different among the applications, e.g., for transmission quality and the like, and it is thus effective to designate different preferences among the applications.

In the present embodiment the user or the applications designated the preference, but the IP mobility protocols may designate the preference. Since the IP mobility protocols sometimes have some control

modes and execute different control procedures, the requirements for the link can differ among the control modes. In this case, it is effective that the IP mobility protocols designate either of different preferences and provide it for the link manager at every switching of the operating mode.

For example, when detecting that there occurs no transmission of packet for a fixed period, the IP mobility protocols switch the operating mode from a control mode that permits continuous transmission of packets, to a control mode that permits intermittent transmission of packets. The former will be referred to as an active mode and the latter as a sleep mode. On the other hand, when a need arises for continuous transmission of packets in the control mode of the sleep mode, the IP mobility protocols switch the control mode to the active mode.

When switching the control mode from the active mode to the sleep mode, the IP mobility protocols request the link manager to preferentially select a link where the sleep mode support is active. The link manager selects a link where the sleep mode support is active in accordance with this request. At the link where the sleep mode support is active, power consumption can be reduced, for example, by intermittent operation of the receiver.

Further, the present embodiment was described about the method wherein the user or the applications selected either of the predetermined preferences, but the system may also be configured so that the user or the applications can arbitrarily set an order of comparative priorities of the link metrics.

The present embodiment was configured to select only one best link and provide it for the IP mobility protocols, but another potential configuration is such that a predetermined number of links are selected to be provided for the IP mobility protocols. In this configuration, it becomes feasible to raise the transmission success rate of packets in such a way that the IP mobility protocols make copies of each single packet and transmit them through a plurality of links, or to increase the throughput in such a way that different packets are transmitted through a plurality of links.

Further, the present embodiment was described about the operation carried out when only one link of each kind was installed on the mobile host, but the present invention is also applicable to configurations wherein a plurality of links of the same kind are installed on the mobile host. For example, in the case where in a cellular communication system the mobile host can simultaneously handle a plurality of links

provided by visiting and surrounding base stations, the link manager is allowed to select a link of an optimal base station, based on the preference.

The link manager according to the present invention is configured to comprise the detecting means for detecting what link is installed; the managing means for defining a plurality of link metrics indicating the characteristics of each detected link and managing the data corresponding to the respective link metrics on the table; and the selecting means for selecting a link having the link metrics complying with the given condition.

According to the present invention, a link complying with the condition requested by the user or the applications is automatically selected out of the plurality of various links installed on the mobile host, which makes it feasible to provide comfortable connection environments for the user of the mobile host.

From the invention thus described, it will be obvious that the embodiments of the invention may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended for inclusion within the scope of the following claims.